Status of the COSY Electron Cooler

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Abstract

The COSY electron cooler has been designed for a maximum electron energy of 100 keV and a maximum current of 4 A in a 25.4 mm diameter electron beam. The final design of the electron gun and the collector, the main magnets and the correction coils, the vacuum system, and the high voltage system will be described. The status of the electron cooler as well as the results of the magnetic field measurements will be reported.

1. INTRODUCTION

Table 1 gives an overview over the main design parameters of the COSY electron cooler. Design goal for the COSY electron cooler is highest performance at low energies to achieve an optimum phase space density between injection energy and 180 MeV. For the cooling of high energy beams above 800 MeV the COSY stochastic cooling system will be installed [1].

Table 1: Design parameters of the COSY electron cooler

free length	7.16 m
cooling section length	2 m
$\beta_{hor}/\beta_{vert}/D$	4.3 m/4.8 m/0 m
electron energy	20 - 100 keV
gun perveance	0.9 μP
electron current	2 - 4 A
diameter of e-beam	2.54 cm
magnetic field	0.08 - 0.15 T
cooling times	1 - 4 s

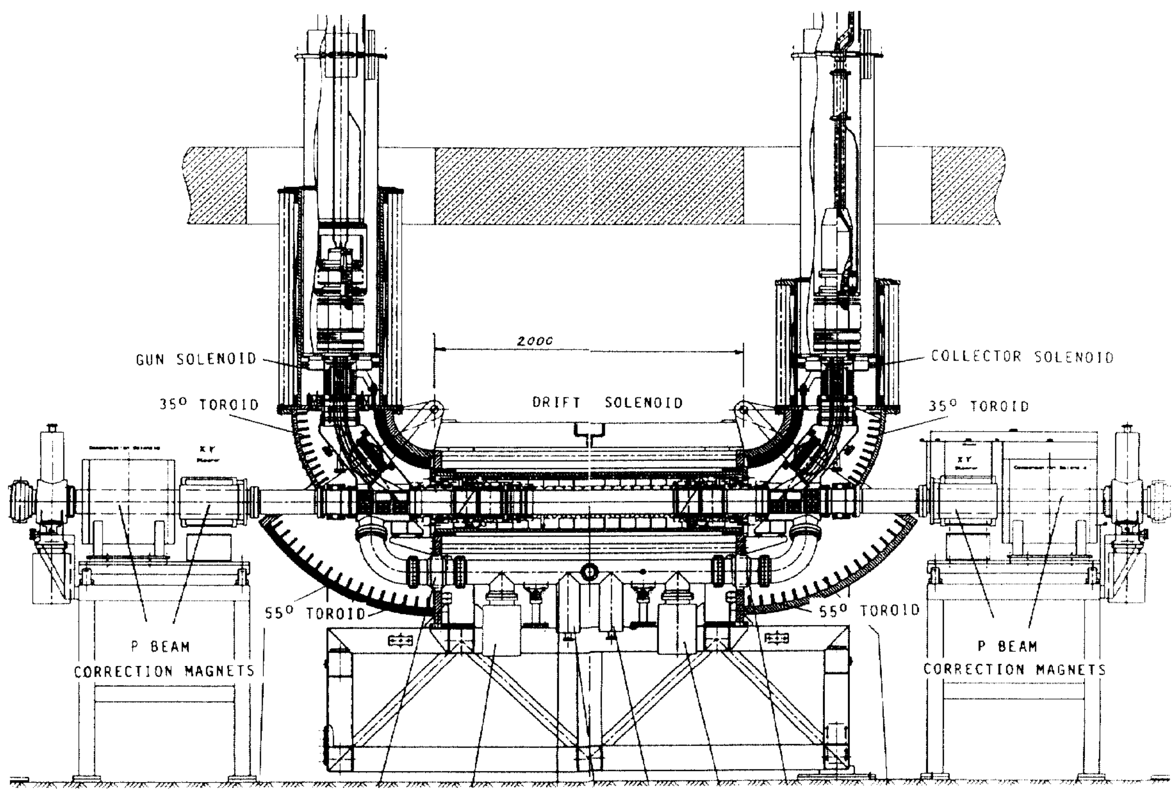

Figure 1: The COSY electron cooler

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2. THE MAGNETIC COMPONENTS

The electron cooler magnets have been delivered by SCANDITRONIX MAGNET in summer 1991. All cooler magnets, i.e. gun, drift and collector solenoids as well as two 55° and two 35° toroids, are connected in series to one common power supply [2]. Active shunts across the gun and drift solenoids provide the necessary current correction in order to have a constant magnetic field along the electron beam path. Two proton beam compensating solenoids to be installed in the cooler telescope in front of and behind the cooler magnetic system, Figure 1, will also be included in the series connection in order to give a highest possible compensation stability.

2.1 Longitudinal field measurements

Longitudinal field measurements are being carried out with the same equipment as it was used for the CELSIUS electron cooler measurements [3]. A longitudinal Gaussmeter probe mounted in a "mouse" was drawn through a closed Al rail in the center of the solenoids and toroids. The measured field values were continuously recorded on an X Y line recorder.

After adjustment of the active shunt currents, the longitudinal correction coils between solenoids and toroids (gap coils) were trimmed to minimize the longitudinal field fluctuations. In Figure 2 the longitudinal field is plotted as a function of the position along the electron beam axis. These measurements were carried out at a main current of 875 A, corresponding to 0.12 T. Field measurements at 0.11 T and at 0.135 T have proven that the setting of the shunts and the correction coil currents scale linearly with the field.

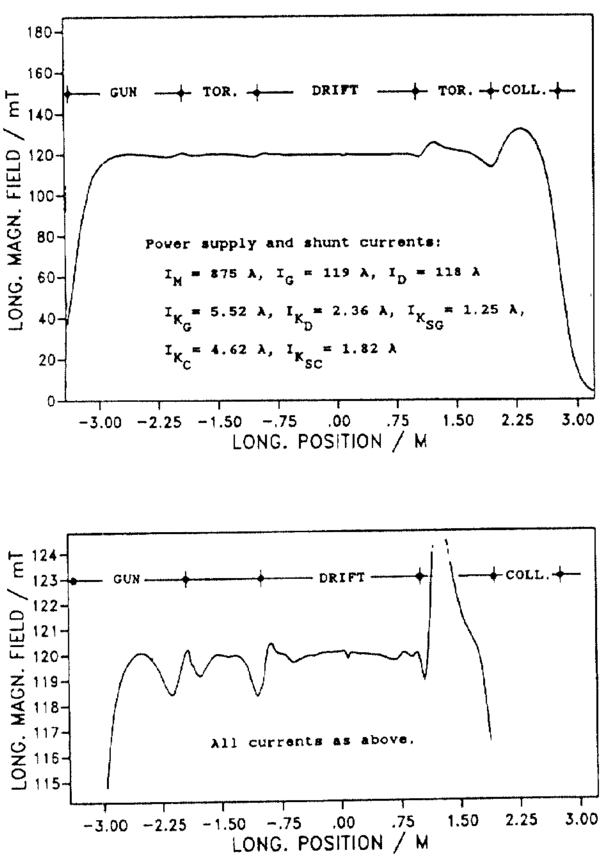

Figure 2: Longitudinal magnetic field in the COSY electron cooler after the adjustment of the shunt and correction coil currents

2.2 Transverse Field Measurements

The purpose of the transverse field measurements is to detect transverse field components in the drift solenoid where electron cooling takes place, and to improve the field quality by transverse correction coils. The goal is to get a ratio of $B_{hor,\ vert.} / B_{long.}$ close to 10^{-4}. These measurements were carried out with the autocollimation method similar to the Heidelberg TSR-measurements [4]. A small mirror hung on gimbals is moved into the magnetic field. A soft-iron bolt connected to the mirror orients itself according to the field lines. The autocollimator registers the angular deviation of the mirror from the optical axis of the system in both transverse planes. In Figure 3 the horizontal and vertical angular deviations in the drift solenoid region before correction are displayed.The tranverse field quality is in the order of ± 0.5 mrad over an effective cooling region between -70 cm and +70 cm.

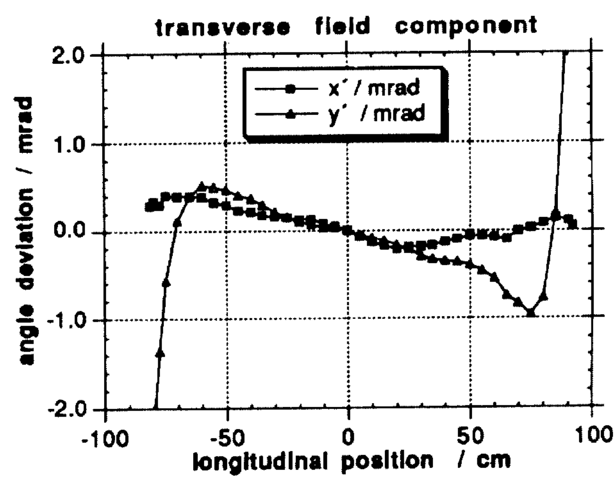

Figure 3: Horizontal and vertical magnetic field components along the beam axis within the drift solenoid region

3. GUN AND COLLECTOR

Gun and collector of the COSY electron cooler have been designed for electron energies between 20 and 100 keV. This allows cooling of protons between 36 and 180 MeV.

The gun design follows the concept of an adiabatic gun, which allows separate adjustment of electron energy and electron current. The mechanical design was optimized with respect to lowest possible transverse electrical field strengths, especially in the gun cathode - anode region to avoid penning discharges. Figure 4 shows the mechanical design of gun and collector. In Figure 5 results of EGUN-calclulations [5] for the electron beam trajectories at 100 keV/4 A are displayed.

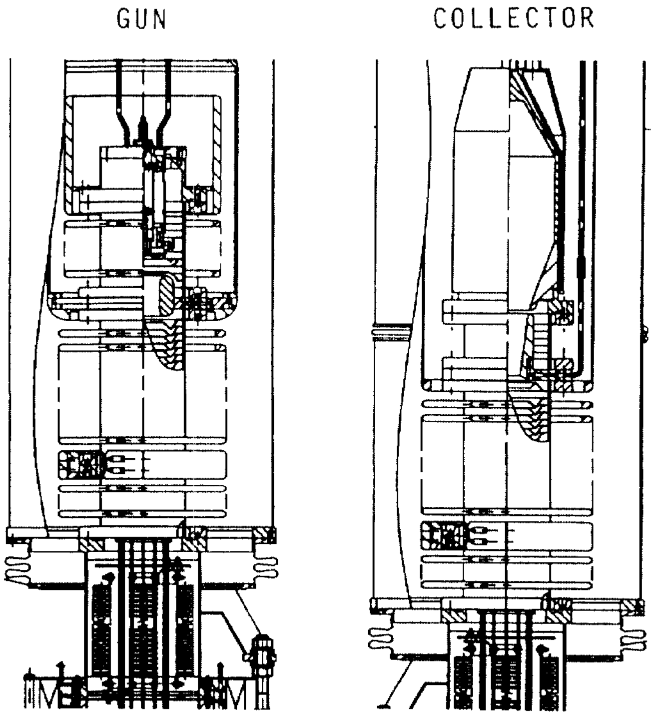

Figure 4: Mechanical design of gun and collector

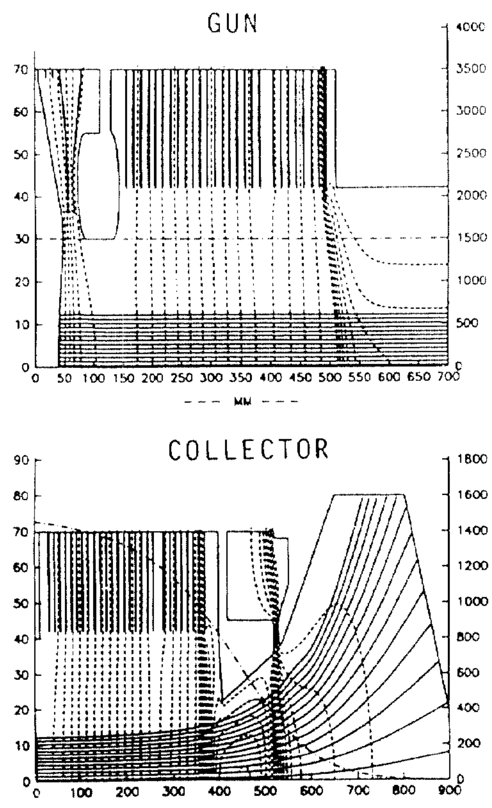

Figure 5: Electron beam trajectories at 100 keV/4 A, calculated with EGUN

Acceleration and deceleration structures for gun and collector consist of NEC tubes. Both gun and collector have been manufactured by the company NTG and are now being mounted for vacuum tests in the KFA. The Ba dispenser cathode will be delivered by SPECTRAMAT.

4. VACUUM SYSTEM

The main components of the vacuum system are delivered and are under test in the separate test setup. The electron cooler will be equipped with a turbopump set, ion getter and Ti sublimation pumps as well as NEG pumps in the vacuum chambers below gun and collector and in the toroid vacuum chambers. Special care has to be taken for heat protection of the NEC tubes during the activation heating of the NEG pumps. Mounting of the vacuum system into the magnet system is envisaged for May this year.

5. HIGH VOLTAGE SYSTEM

The Faraday cage and the high voltage plattform have been installed in the COSY hall. The 100 keV power supply, the various power supplies for gun and collector anodes as well as the 8 kV/5 A collector power supply have been delivered. They will be installed on the HV-plattform during May this year.

6. TIME SCHEDULE

All major components for the electron cooler are delivered and are in the stage of testing. After the magnetic field measurements the vacuum system will be mounted during May this year, including gun and collector. Installation of the high voltage system is scheduled for May, too. This gives us the chance of first electron beam tests in the test position outside the ring and optimization during summer. Installation of the electron cooler in the final position in the ring and start of cooling experiments is envisaged for autumn this year after the first comissioning of the COSY ring [6].

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